US009075590B2

(12) **United States Patent**
Hung et al.

(10) **Patent No.: US 9,075,590 B2**
(45) **Date of Patent: Jul. 7, 2015**

(54) **VOLTAGE IDENTIFICATION DEFINITION REFERENCE VOLTAGE GENERATION CIRCUIT AND BOOT VOLTAGE GENERATING METHOD THEREOF**

(71) Applicant: **uPI Semiconductor Corp.**, Hsinchu County (TW)

(72) Inventors: **Shan-Fong Hung**, Hsinchu County (TW); **Sheng-Hsuan Wang**, Hsinchu County (TW)

(73) Assignee: **uPI Semiconductor Corp.**, Hsinchu County (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 96 days.

(21) Appl. No.: **13/778,151**

(22) Filed: **Feb. 27, 2013**

(65) **Prior Publication Data**

US 2014/0129851 A1 May 8, 2014

(30) **Foreign Application Priority Data**

Nov. 6, 2012 (TW) ..... 101141203 A

(51) **Int. Cl.**
G05F 3/16 (2006.01)
G06F 1/26 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 1/26*** (2013.01)

(58) **Field of Classification Search**
CPC G06F 1/26; G05F 3/30; G05F 3/26; H03M 11/04
USPC 323/222–225, 233–235, 271–275, 323/282–285, 313
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,710,970	A *	12/1987	Wu et al.	455/113
4,961,057	A *	10/1990	Ibukuro	330/295
RE33,941	E *	5/1992	Lorincz et al.	361/87
5,138,192	A *	8/1992	Hsu	327/50
5,452,700	A *	9/1995	Matsuura	123/490
5,515,830	A *	5/1996	Arakowa	123/490
5,691,605	A *	11/1997	Xia et al.	315/307
5,941,216	A *	8/1999	Arakawa	123/490
6,016,260	A *	1/2000	Heeringa	363/21.18
6,184,669	B1 *	2/2001	Matsuo	323/303
6,483,684	B2 *	11/2002	Isobe	361/93.9
6,657,475	B1 *	12/2003	Zahn	327/309
7,358,710	B2 *	4/2008	Luo et al.	323/282
7,715,216	B2 *	5/2010	Liu et al.	363/89
RE43,946	E *	1/2013	Sase et al.	323/283
8,890,494	B2 *	11/2014	Gasperi	323/266
2004/0150928	A1 *	8/2004	Goodfellow et al.	361/90
2009/0195304	A1 *	8/2009	Bankman et al.	327/552
2009/0213629	A1 *	8/2009	Liu et al.	363/89
2010/0001702	A1 *	1/2010	Tateishi	323/282
2012/0134516	A1 *	5/2012	Prentice et al.	381/123
2012/0326631	A1 *	12/2012	Naruo et al.	315/297

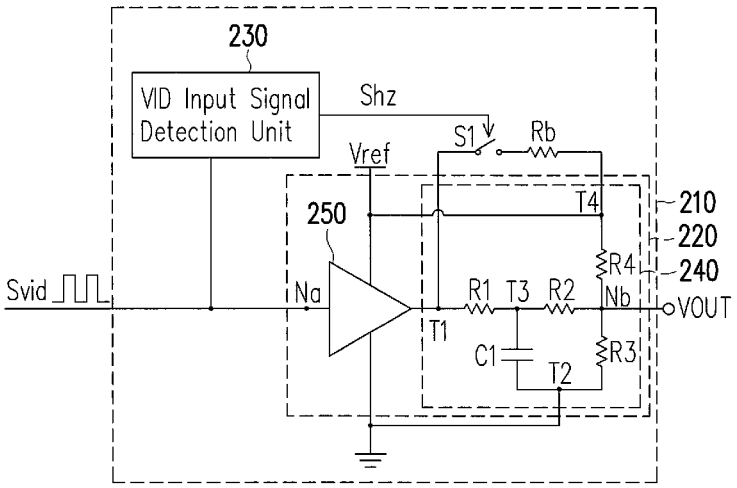
* cited by examiner

Primary Examiner — Timothy J Dole
Assistant Examiner — Yusef Ahmed
(74) *Attorney, Agent, or Firm* — Jianq Chyun IP Office

(57) **ABSTRACT**

A voltage identification definition (VID) reference voltage generation circuit and a boot voltage generating method thereof are provided. In the boot voltage generating method, a VID reference voltage generation circuit is provided. The VID reference voltage generation circuit includes a preset voltage providing unit, a switch and a VID input signal detection unit. When the VID input signal detection unit detects no input of a VID signal, a control signal is generated to control the switch, such that the preset voltage providing unit provides an adjustable preset voltage.

11 Claims, 5 Drawing Sheets



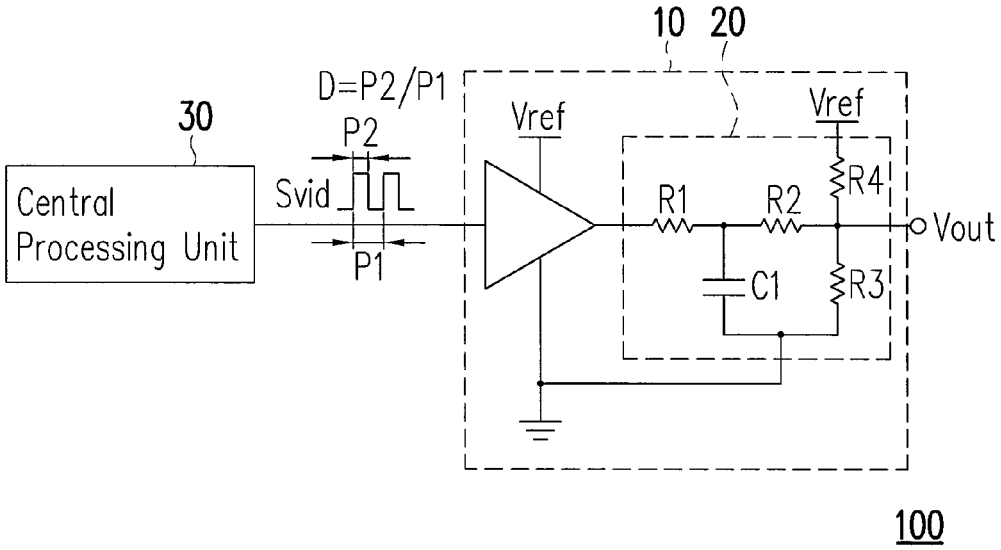


FIG. 1 (RELATED ART)

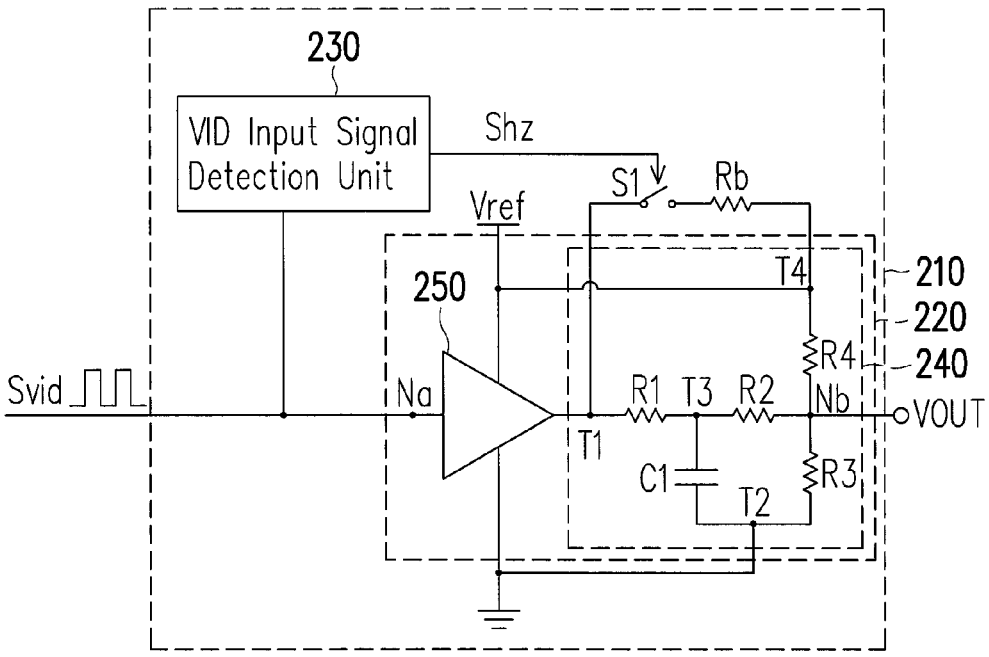


FIG. 2A

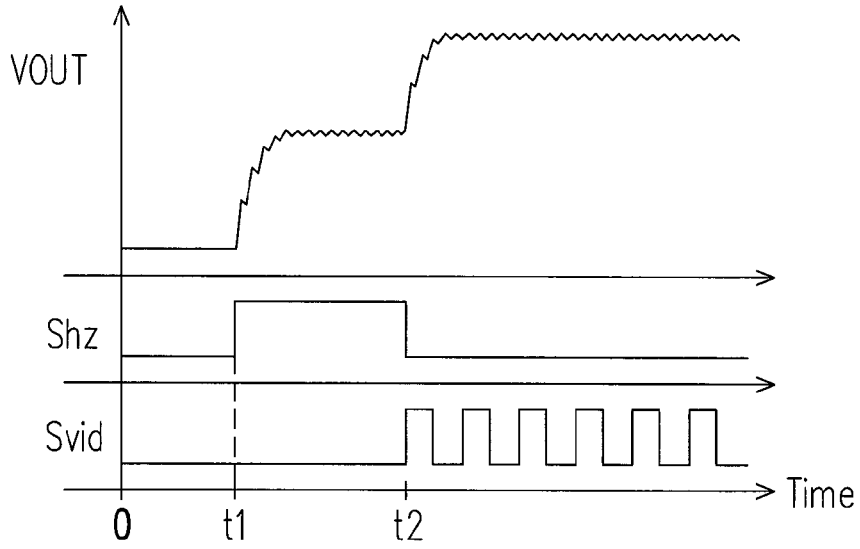


FIG. 2B

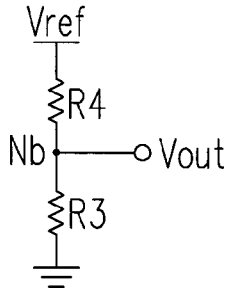


FIG. 2C

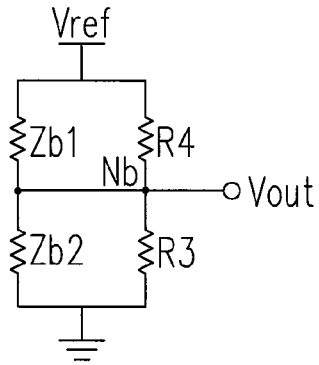


FIG. 2D

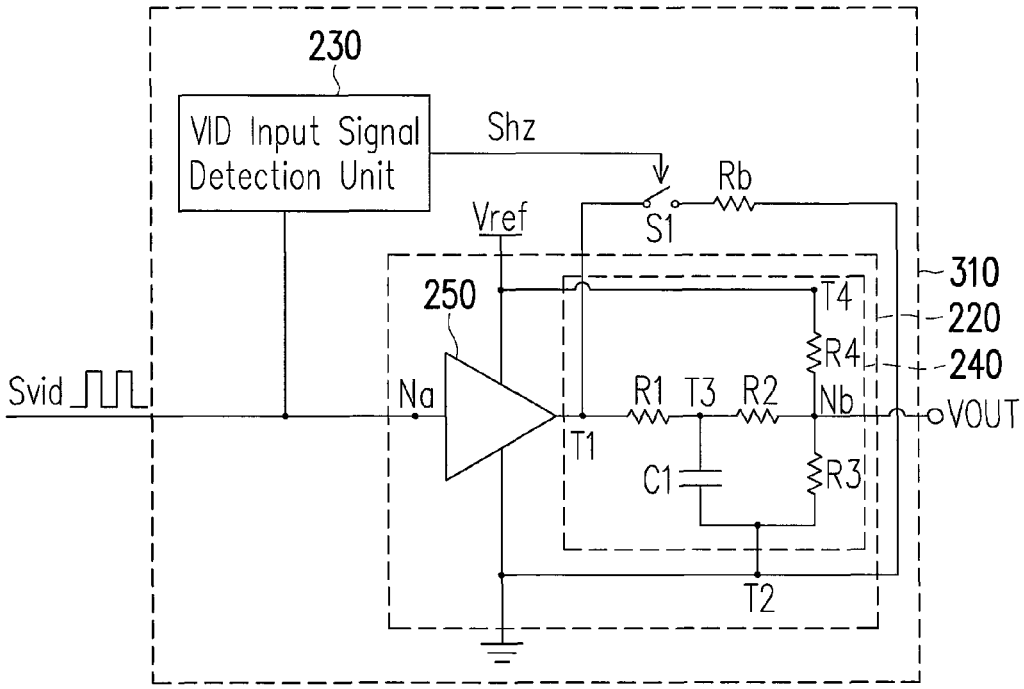

230
VID Input Signal Detection Unit
Shz
Rb
S1
Vref
250
T4
R4
310
220
240
Svid
Na
R1
T3
R2
Nb
VOUT
T1
C1
R3
T2

FIG. 3

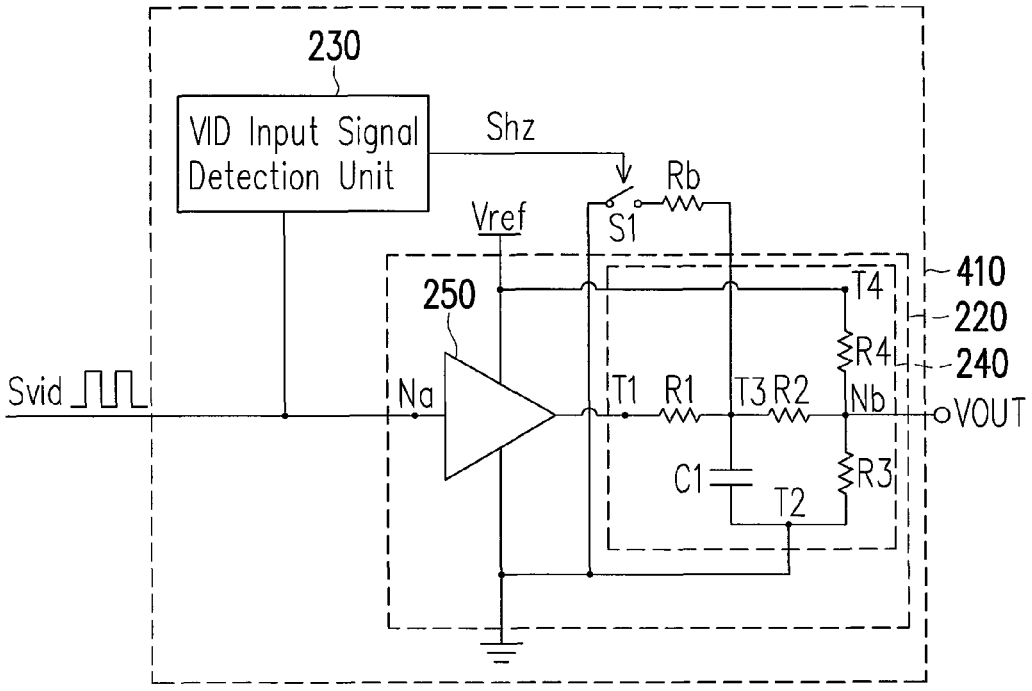

230
VID Input Signal Detection Unit
Shz
Rb
S1
Vref
250
T4
410
220
R4
240
Svid
Na
T1
R1
T3
R2
Nb
VOUT
C1
R3
T2

FIG. 4

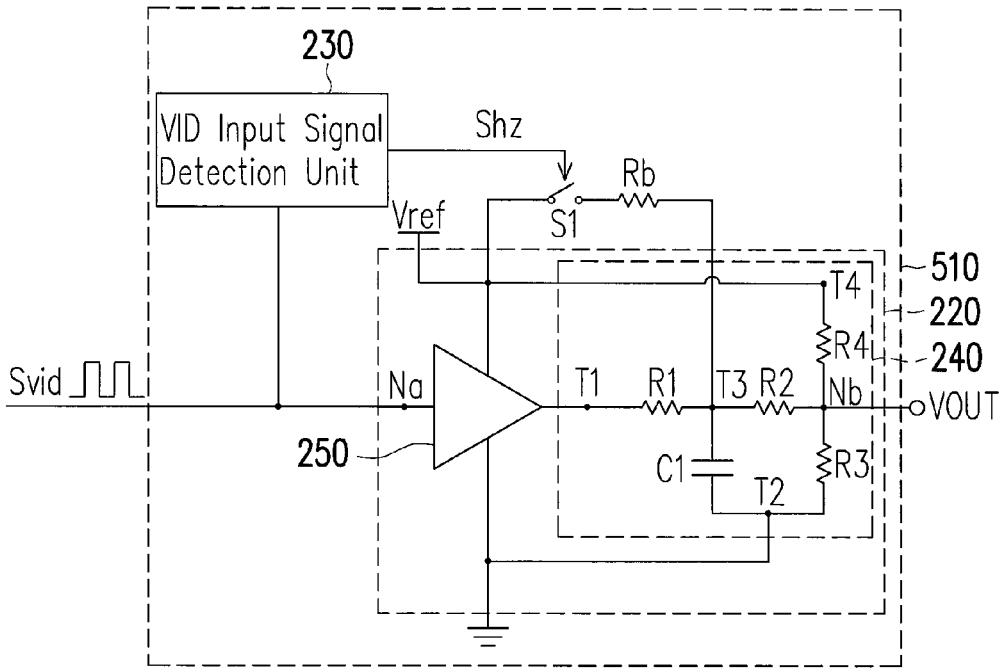

230
VID Input Signal Detection Unit
Shz
Rb
Vref
S1
510
220
240
T4
R4
Svid
Na
T1
R1
T3
R2
Nb
VOUT
250
C1
R3
T2

FIG. 5

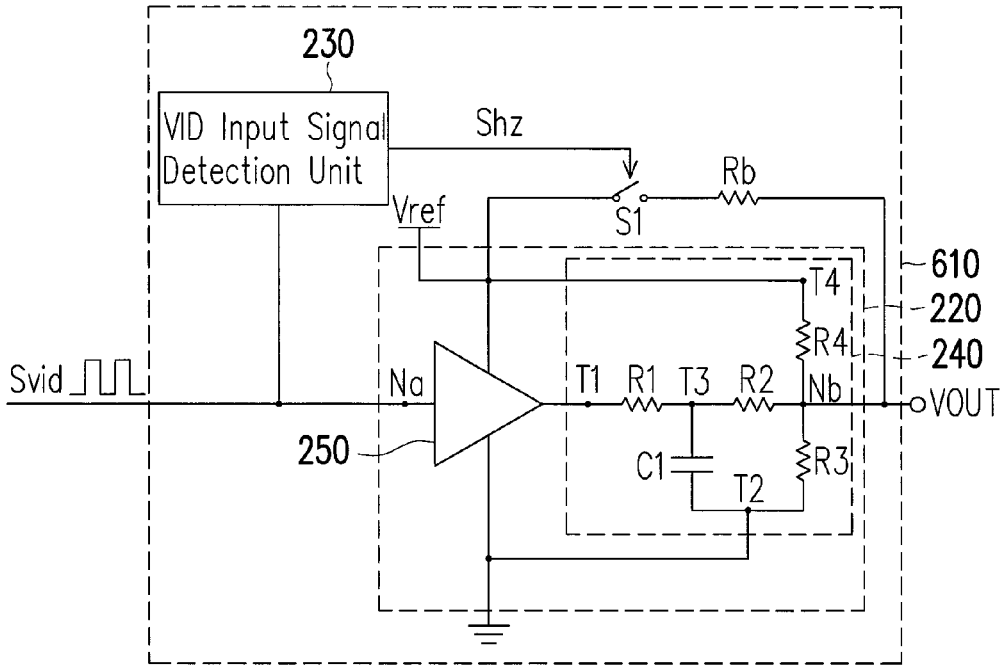

230
VID Input Signal Detection Unit
Shz
Rb
Vref
S1
610
220
240
T4
R4
Svid
Na
T1
R1
T3
R2
Nb
VOUT
250
C1
R3
T2

FIG. 6

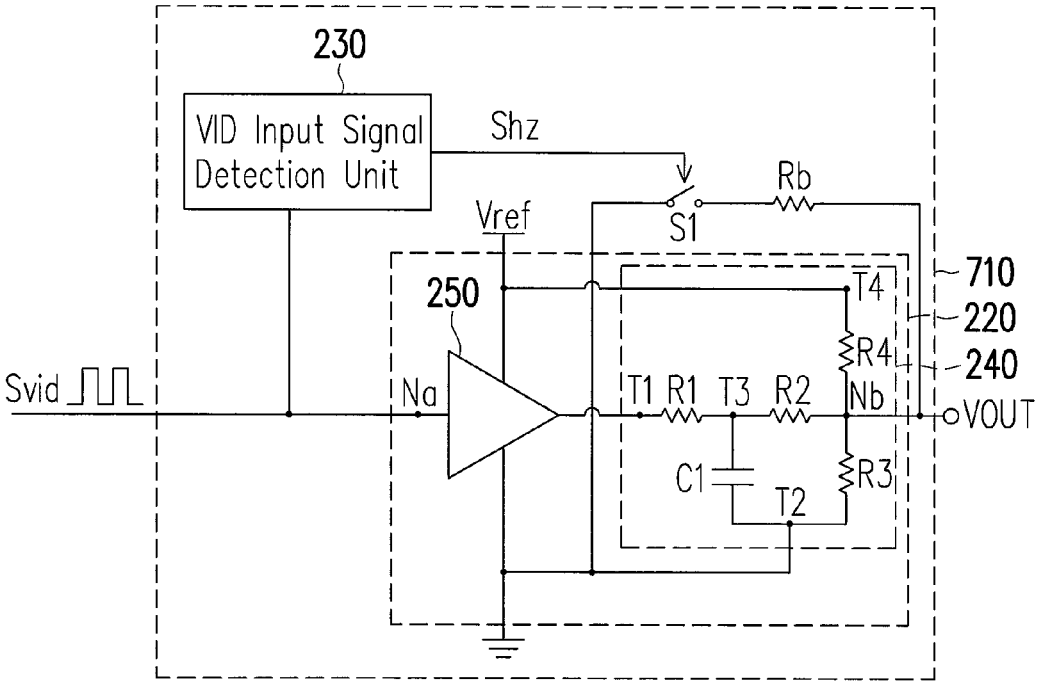

230
VID Input Signal Detection Unit
Shz
Rb
S1
Vref
250
710
220
240
T4
R4
Svid
Na
T1 R1 T3 R2
Nb
VOUT
C1
R3
T2

FIG. 7

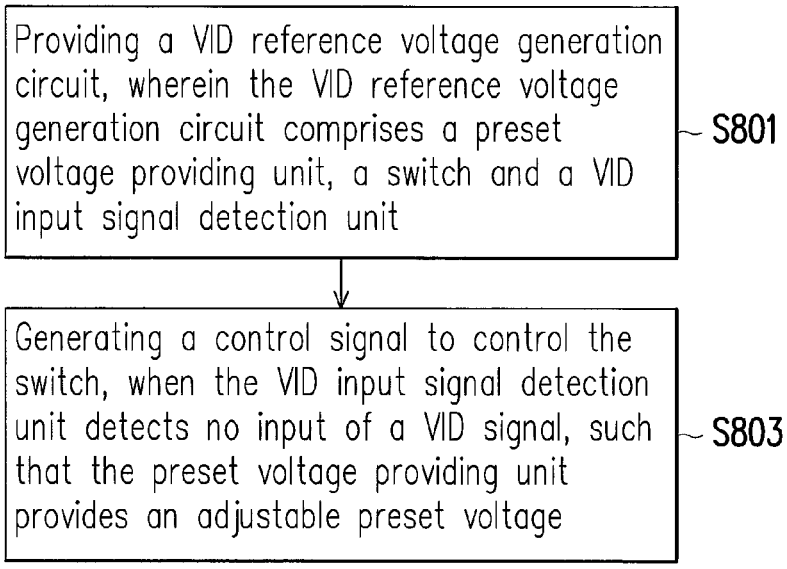

Providing a VID reference voltage generation circuit, wherein the VID reference voltage generation circuit comprises a preset voltage providing unit, a switch and a VID input signal detection unit
S801
Generating a control signal to control the switch, when the VID input signal detection unit detects no input of a VID signal, such that the preset voltage providing unit provides an adjustable preset voltage
S803

FIG. 8

VOLTAGE IDENTIFICATION DEFINITION REFERENCE VOLTAGE GENERATION CIRCUIT AND BOOT VOLTAGE GENERATING METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority benefit of Taiwan application serial no. 101141203, filed on Nov. 6, 2012. The entirety of the above-mentioned patent application is hereby incorporated by reference herein and made a part of this specification.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a boot voltage technology, and more particularly, to a voltage identification definition (VID) reference voltage generation circuit and a boot voltage generating method.

2. Description of Related Art

FIG. **1** is a block diagram of a conventional pulse width modulation voltage identification definition (PWMVID) reference voltage generator. Typically, a computer system **100** includes a PWMVID reference voltage generator **10**. The PWMVID reference voltage generator **10** includes a resistor-capacitor network **20**. The resistor-capacitor network **20** consists of resistors R1 to R4 and capacitor C1.

When the computer system **100** normally operates, a central processing unit (CPU) **30** generates a VID signal Svid with a duty cycle. The duty cycle D of this PWMVID signal Svid is equal to P2/P1, where P1 is a time duration of a cycle and P2 is a time duration of logic high level. After receiving the VID signal Svid, the PWMVID reference voltage generator **10** generates an output voltage Vout through the resistor-capacitor network **20**. During normal operation, the output voltage Vout can be adjusted according to the VID signal Svid. The convenience of this technique includes that a slew rate of the VID signal Svid can be adjusted and the value of the output voltage Vout can also be adjusted. To a user, therefore, this technique has great freedom to adjust.

However, when the computer system **100** boots up, the central processing unit **30** has not transmitted the VID signal Svid to the PWMVID reference voltage generator **10** and, therefore, the output voltage Vout is a fixed value which cannot be adjusted. In other words, the output voltage Vout when the computer system **100** just boots up is determined by the reference voltage Vref and the resistors R3, R4.

Since the output voltage Vout when the computer system just boots up is fixed, the user is not able to decide the voltage value. The output voltage Vout when the computer system just boots up can also be referred to as a boot voltage. In some cases, the boot voltage needs to be a particular voltage value to execute a particular procedure. A particular procedure may not be executed immediately because the boot voltage is not equal to the particular voltage value.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a VID reference voltage generation circuit and a boot voltage generating method thereof for addressing the above described problem.

The present invention provides a voltage identification definition (VID) reference voltage generation circuit including a preset voltage providing unit, a switch and a VID input signal detection unit. The switch is coupled to the preset voltage providing unit. The VID input signal detection unit is coupled to an input terminal of the preset voltage providing unit. When detecting no input of a VID signal, the VID input signal detection unit generates a control signal to control the switch such that the preset voltage providing unit provides an adjustable preset voltage.

Viewed from another view point, the present invention provides a boot voltage generating method. In this method, a VID reference voltage generation circuit is provided. The VID reference voltage generation circuit includes a preset voltage providing unit, a switch and a VID input signal detection unit. When the VID input signal detection unit detects no input of a VID signal, a control signal is generated to control the switch, such that the preset voltage providing unit provides an adjustable preset voltage.

In one embodiment, the preset voltage providing unit includes a resistor-capacitor network, and the resistor-capacitor network receives a reference voltage.

In one embodiment, when the switch is turned on, it changes a voltage of a voltage division node of the resistor-capacitor network, and the voltage division node provides the adjustable preset voltage.

In one embodiment, the switch is coupled to a terminal of the resistor-capacitor network.

In one embodiment, the switch is coupled to a terminal, an internal node or a voltage division node of the resistor-capacitor network through a resistor, the voltage division node provides the adjustable preset voltage.

In one embodiment, the VID signal may be of a series VID signal type, a parallel VID signal type or a pulse modulation VID signal type.

In view of the foregoing, the VID reference voltage generation circuit and boot voltage generating method of the present invention can immediately provide the adjustable preset determined VOUT at the time, for example, when the computer system just boots up, without affecting the original VID characteristics. Therefore, the present VID reference voltage generation circuit and boot voltage generating method have greater freedom in its application.

Other objectives, features and advantages of the present invention will be further understood from the further technological features disclosed by the embodiments of the present invention wherein there are shown and described preferred embodiments of this invention, simply by way of illustration of modes best suited to carry out the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

FIG. **1** is a block diagram of a conventional pulse width modulation voltage identification definition (PWMVID) reference voltage generator.

FIG. **2**A is a block diagram of a VID reference voltage generation circuit according to one embodiment of the present invention.

FIG. **2**B illustrates a timing sequence of a VID reference voltage generation circuit according to one embodiment of the present invention.

FIG. **2**C is a view showing resistors at a voltage division node Nb at the time the computer system just boots up and the switch S1 has not been turned on.

FIG. **2**D is a view showing resistors at the voltage division node Nb at the time the computer system just boots up and the switch S1 is turned on.

FIG. **3** to FIG. **7** are block diagrams of the VID reference voltage generation circuits according embodiments of the present invention.

FIG. **8** is a flow chart of a boot voltage generating method according to one embodiment of the present invention.

DESCRIPTION OF THE EMBODIMENTS

Reference will now be made in detail to the exemplary embodiments of the invention, examples of which are illustrated in the accompanying drawings. In addition, whenever possible, identical or similar reference numbers stand for identical or similar elements in the figures and the embodiments.

FIG. **2**A is a block diagram of a voltage identification definition (VID) reference voltage generation circuit according to one embodiment of the present invention. FIG. **2**B illustrates a timing sequence of the VID reference voltage generation circuit of FIG. **2**A. Referring to FIG. **2**A and FIG. **2**B, the VID reference voltage generation circuit **210** may be utilized in a computing system. The VID reference voltage generation circuit **210** includes a preset voltage providing unit **220**, a switch S1 and a VID reference voltage input signal detection unit **230**. The switch S1 is coupled to the preset voltage providing unit **220**. The VID input signal detection unit **230** is coupled to an input terminal Na of the pre-set voltage providing unit **220**.

The preset voltage providing unit **220** includes a resistor-capacitor network **240** and a buffer **250**, and the resistor-capacitor network **240** receives a reference voltage Vref. The resistor-capacitor network **240** includes resistors R1 to R4 and a capacitor C1. It is noted that the resistor-capacitor network **240** of the present invention should not be limited in its configuration to any particulars described herein.

The switch S1 is coupled to a terminal of the resistor-capacitor network **240**. In addition, the switch S1 may further be coupled to another terminal, an internal node or a voltage division node of the resistor-capacitor network through a resistor Rb. The voltage division node provides an adjustable preset voltage. In FIG. **2**A, a first terminal of the switch S1 is coupled to a terminal T1. A second terminal of the switch S1 is coupled to a terminal T4 through the resistor Rb.

In a typical computer system, a VID signal Svid generated by a central processing unit varies according to its work mode so as to dynamically adjust its operation voltage (or core voltage) to save power consumption. The VID signal Svid may be of a series VID type, a parallel VID type or a pulse modulation VID type.

After a period of time (e.g. time 0 to t1) after the VID input signal detection unit **230** detects no input of the VID signal Svid (e.g. when the computer system just boots up or there is completely no VID signal Svid, and a detected result of the VID input signal detection unit **230** is a high impedance state), then at time t1, a logic high level control signal Shz may be generated to control the switch S1. After the switch S1 is turned on, the preset voltage providing unit **220** is enabled to provide an adjustable preset voltage VOUT.

In addition, at time t2, because the VID input signal detection unit **230** detects an input of the VID signal Svid, the control signal Shz generated turns from logic high level to a logic low level, such that the switch S1 is not turned on. After the time t2, the operation of the VID reference voltage generation circuit **210** is no longer affected by the switch S1. The preset voltage providing unit **220** restores to its original operation characteristic. For example, its output voltage is the adjustable preset voltage VOUT that can be adjusted according to the VID signal Svid.

FIG. **2**C is a view showing resistors at a voltage division node Nb at the time the computer system just boots up and the switch S1 has not been turned on. FIG. **2**D is a view showing resistors at the voltage division node Nb at the time the computer system just boots up and the switch S1 is turned on.

In FIG. **2**C, the adjustable preset voltage VOUT is related to the reference voltage Vref and the resistors R3 and R4. The adjustable preset voltage VOUT may be expressed by Equation 1 below.

$$VOUT_{S1_OFF} = Vref \times \frac{R3}{R3 + R4} \quad \text{(Equation 1)}$$

Referring to FIG. **2**A and FIG. **2**D, in FIG. **2**D, turn-on of the switch S1 changes the voltage of the voltage division node Nb of the resistor-capacitor network **220**, and the voltage division node Nb provides the adjustable preset voltage VOUT. The resistors Rb, R1, R2 and capacitor C1 can form impedance Zb1 and Zb2. Therefore, the adjustable preset voltage VOUT is related to the reference voltage Vref, resistors R3, R4 and impedance Zb1, Zb2. The adjustable preset voltage VOUT may be expressed by Equation 2 below.

$$VOUT_{S1_ON} = Vref \times \frac{Zb2 \| R3}{Zb2 \| R3 + Zb1 \| R4} \quad \text{(Equation 2)}$$

In general, $VOUT_{S1_OFF}$ is 0.9V, $VOUT_{S1_ON}$ can be adjusted to 0.5V to 1.5V.

In view of the above description, the VID reference voltage generation circuit **210** can immediately provide the adjustable preset determined VOUT at the time, for example, when the computer system just boots up, without affecting the original VID characteristics. Therefore, the present VID reference voltage generation circuit **210** has greater freedom in its application.

On the other hand, coupling of the switch S1 is not limited to the particular way shown in FIG. **2**A. Rather, the switch S1 may be coupled in a variety of ways as exemplified below. FIG. **3** to FIG. **7** are block diagrams of the VID reference voltage generation circuits according embodiments of the present invention. The VID reference voltage generation circuits **310**, **410**, **510**, **610** and **710** are based on the architecture of the VID reference voltage generation circuit **210** and are similar in their structure. As such, parts of the circuits **310**, **410**, **510**, **610** and **710** that are the same as the circuit **210** is not repeated herein.

In FIG. **3**, the first terminal of the switch S1 is coupled to the terminal T1 of the resistor-capacitor network **240**. The second terminal of the switch S1 is coupled to the terminal T2 of the resistor-capacitor network **240** through the resistor Rb.

In FIG. **4**, the first terminal of the switch S1 is coupled to the terminal T2 of the resistor-capacitor network **240**. The second terminal of the switch S1 is coupled to the internal node T3 of the resistor-capacitor network **240** through the resistor Rb.

In FIG. **5**, the first terminal of the switch S1 is coupled to the terminal T4 and reference voltage Vref of the resistor-capacitor network **240**. The second terminal of the switch S1 is coupled to the internal node T3 of the resistor-capacitor network **240** through the resistor Rb.

In FIG. **6**, the first terminal of the switch S1 is coupled to the terminal T4 and reference voltage Vref of the resistor-capacitor network **240**. The second terminal of the switch S1 is coupled to the voltage division node Nb of the resistor-capacitor network **240** through the resistor Rb. The voltage division node Nb provides the adjustable preset voltage VOUT.

In FIG. **7**, the first terminal of the switch S1 is coupled to the terminal T2 of the resistor-capacitor network **240**. The second terminal of the switch S1 is coupled to the voltage division node Nb of the resistor-capacitor network **240** through the resistor Rb.

Based on the descriptions disclosed in the aforementioned exemplary embodiments, a boot voltage generating method may be briefed below. More specifically, FIG. **8** is a flow chart of a boot voltage generating method according to one embodiment of the present invention. Referring to FIG. **2**A and FIG. **8**, the boot voltage generating method of the present embodiment can include the following steps:

providing the VID reference voltage generation circuit **210**, wherein the VID reference voltage generation circuit **210** comprises the preset voltage providing unit **220**, the switch S1 and the VID input signal detection unit **230** (step S**810**), and

generating the control signal Shz to control the switch S1, when the VID input signal detection unit **230** detects no input of the VID signal Svid, such that the preset voltage providing unit **220** provides the adjustable preset voltage VOUT (step S**803**). The embodiment of FIG. **2**D may be referred to for an understanding of the voltage in this step. $VOUT_{S1_ON}$ may be adjusted within the range from 0.5 to 1.5V.

In summary, the VID reference voltage generation circuit and boot voltage generating method of the present invention can immediately provide the adjustable preset determined VOUT at the time, for example, when the computer system just boots up, without affecting the original VID characteristics. Therefore, the present VID reference voltage generation circuit and boot voltage generating method have greater freedom in its application.

Although the invention has been described with reference to the above exemplary embodiments, it will be apparent to one of ordinary skill in the art that modifications to the described exemplary embodiments may be made without departing from the spirit of the invention. Accordingly, the scope of the invention will be defined by the attached claims and not by the above detailed descriptions.

What is claimed is:

1. A voltage identification definition reference voltage generation circuit comprising:

a preset voltage providing unit;

a switch coupled to the preset voltage providing unit; and

a voltage identification definition input signal detection unit coupled to an input terminal of the preset voltage providing unit, the voltage identification definition input signal detection unit generates a control signal to control the switch to turn on, when detecting no input of a voltage identification definition signal, such that a voltage division node of the preset voltage providing unit provides an adjustable preset voltage, wherein when the voltage identification definition input signal detection unit detects an input of the voltage identification definition signal, the switch is turned off.

2. The voltage identification definition reference voltage generation circuit according to claim **1**, wherein the preset voltage providing unit comprises a resistor-capacitor network, and the resistor-capacitor network receives a reference voltage.

3. The voltage identification definition reference voltage generation circuit according to claim **2**, wherein when the switch is turned on, it changes a voltage of a voltage division node of the resistor-capacitor network, and the voltage division node provides the adjustable preset voltage.

4. The voltage identification definition reference voltage generation circuit according to claim **2**, wherein the switch is coupled to a terminal of the resistor-capacitor network.

5. The voltage identification definition reference voltage generation circuit according to claim **2**, wherein the switch is coupled to a terminal, an internal node or a voltage division node of the resistor-capacitor network through a resistor, the voltage division node provides the adjustable preset voltage.

6. The voltage identification definition reference voltage generation circuit according to claim **1**, wherein the voltage identification definition signal is one of a series voltage identification definition signal type, a parallel voltage identification definition signal type and a pulse modulation voltage identification definition signal type.

7. A boot voltage generating method comprising:

providing a voltage identification definition reference voltage generation circuit, wherein the voltage identification definition reference voltage generation circuit comprising a preset voltage providing unit, a switch and a voltage identification definition input signal detection unit; and

generating a control signal to control the switch to turn on, when the voltage identification definition input signal detection unit detects no input of a voltage identification definition signal, such that a voltage division node of the preset voltage providing unit provides an adjustable preset voltage, wherein when the voltage identification definition input signal detection unit detects an input of the voltage identification definition signal, the switch is turned off.

8. The boot voltage generating method according to claim **7**, wherein the preset voltage providing unit comprises a resistor-capacitor network, and the resistor-capacitor network receives a reference voltage.

9. The boot voltage generating method according to claim **8**, wherein when the switch is turned on, it changes a voltage of a voltage division node of the resistor-capacitor network, and the voltage division node provides the adjustable preset voltage.

10. The boot voltage generating method according to claim **8**, wherein the switch is coupled to a terminal of the resistor-capacitor network.

11. The boot voltage generating method according to claim **7**, wherein the voltage identification definition signal may be of a series voltage identification definition signal type, a parallel voltage identification definition signal type or a pulse modulation voltage identification definition signal type.

* * * * *